CORTHELL, ELMER
Growth and density of population
of great cities.... 1903.

GROWTH AND DENSITY OF POPULATION OF GREAT CITIES OF OVER ONE MILLION INHABITANTS.

At the annual meeting of the American Association for the Advancement of Science, held at Springfield, Mass., in 1895, the author presented a paper to Section "I," with a similar title. The present paper gives the necessary summary of the former paper, and brings the curves and data down generally to the census of 1900, also corrects any errors in the former paper.

In 1886 and 1887, Mr. Rudolph Hering, civil engineer, and at that time chairman of a commission for solving the problem of water supply and drainage of the city of Chicago, compiled some statistics and made a diagram showing the curve of growth of population of several cities in the United States. About the year 1890, for the purpose of presenting in a professional report on a rapid transit question in Chicago a comparison between the several cities shown on Mr. Hering's diagram, the writer extended the diagram to a more recent date. During 1894 he obtained, by an extended correspondence, the necessary information, and plotted on a new diagram the curves of growth of population of several cities of the world numbering over 1,000,000 inhabitants at the present time. These curves were extended forward, as will be seen by an examination of the diagram. Many interesting and instructive features were presented by this comparison, and the value of the results thus presented graphically were at once appreciated by an examination of the diagram.

The density of the population of each city, so far as it could be ascertained, was also shown graphically by squares of various sizes.

The information was obtained from official sources through the author's correspondents, all of whom kindly interested themselves to comply with his requests for data, and to whom he is largely indebted for the reliable character of the figures.

As each city has its peculiarities in history, growth, density and many other features, it is necessary to take up each separately in order to fully understand and appreciate the curves on the diagram.

Before, however, proceeding to the cities separately, there should be given the data which form the basis for the extension of the curves for the last decade. These have all been obtained from official sources and are believed to be correct.

If the diagram is compared with that of 1895, published in Vol. XLIV, page 359 et seq., it will be seen that some of the curves for periods previous to 1890 have been slightly changed. This was done to make them conform to the official figures received subsequent to the publication of the former paper.

- An attempt has been made to give in each case the metropolitan population, regardless of suburban city lines or even State lines, as in the case of New York, where those populations of New Jersey, which are really a part of the metropolitan population of Greater New York, are included.

In the case of Berlin, a personal visit to that city last summer convinced the writer that his former basis of population was misleading, and that there should be a "Greater Berlin" to include the twelve separate cities or districts, which, while an integral part of the metropolitan population, have separate municipal governments. There are twelve of those municipalities which are not included in the population of Berlin, but are included in Greater Berlin. The admirable street-car system has made the population practically a unit.

The data for the diagram for plotting the curves of the last decade are as per the following table, to which has been appended, as a matter of interest, the populations of Germany and the United States, by which it will be seen that the former is growing at a rate of about 16 per cent. per decade and the latter 20 per cent.

DATA FOR DIAGRAM.

London	1900	4,589,129
Greater London	1900	6,652,145
Paris (Greater)	1896	3,308,007
	1901	3,599,991
St. Petersburg	1890	954,400
	1897	1,132,677

Berlin	1893	1,640,994
	1895	1,678,912
	1898	1,801,261
	1900	1,884,157
Greater Berlin......................	1880	1,245,279
	1890	1,848,018
	1895	2,112,366
	1900	2,512,523
Vienna.................................	1894	1,480,572
	1899	1,639,811
Philadelphia.........................	1890	1,105,277
	1900	1,369,632
New York (Manhattan Borough).........................	1890	1,441,216
	1900	1,850,093
Greater New York	1890	2,799,242
	1900	3,833,999
Greater Chicago..................	1890	1,191,922
	1900	1,838,735
GERMANY.................../..........	1880	45,234,061
	1890	49,428,470
	1895	52,279,901
	1900	56,345,014
UNITED STATES...............	1880	50,155,783
	1890	62,622,250
	1900	76,303,387

LONDON.

For the information of those who are not familiar with the peculiar geographical conditions of the population, the following data need to be given in order to have a full understanding of the subject:

LONDON WITHIN VARIOUS BOUNDARIES.	Area in statute acres.
Within the registrar-general's tables of mortality..	74,672
Within the limits of the county of London	75,442
London school-board district	75,442
City of London, within the municipal and parliamentary limits...	671
Central criminal court district	269,140
Metropolitan parliamentary boroughs (exclusive of the city of London)........................	74,771
Same (including the city of London)..............	85,442
Metropolitan police district (not including city of London)...	442,750
Metropolitan and city police districts..............	443,421

The metropolitan police district extends over an area, with a radius of fifteen miles from Charing Cross, 688.31 square miles, exclusive of the "city of London."

The population used in the curve of growth is that included in the registrar-general's area, or "Registration London," which embraces what is called "Water London," as it is the 620 square miles of area supplied by the eight metropolitan water companies.

It is almost impossible in the case of London, as well as that of other cities, to define the area of the metropolitan population, that is, the population of the city itself and of the suburban districts which contain the population doing business in the city. The limits of London could be extended far beyond those of the registrar-general, and with each extension a much different population would be found to exist. To compare, perhaps, more properly with the other cities and cover the metropolitan area, it should be stated that the population supplied by the London water companies in 1892 was estimated to be 5,490,780, and this population was plotted on the author's diagram of 1895. In 1891 the population of "Greater London" (London and the "outer ring") was 5,633,806.

Registration London is (1900)............4,589,129
Greater London   "   " 6,652,145

As to the density of population, that of the White Chapel district is taken as a maximum, being, on the 357 acres included, at the rate of 132,000 per square mile in 1891. The average in the whole of London is 37,000. per square mile.

In the way of further explanations it whould be stated that "Greater London" is the area included within the metropolitan and city police districts, and includes all parishes wholly situate within a circle of fifteen miles' radius from Charing Cross, and all parishes of which any part is included within a circle of twelve miles' radius from the same center. Its total area is 701 square miles, and its population in 1891 was 5,633,332. (See "London Water Supply," a paper presented to the Society of Arts, April 19, 1899, by Walter Hunter, Esq., Member Inst. C. E.)

The present ratio of increase per decade is as follows :

Greater London................................. 20 per cent.
London...8.6 per cent.

GREATER NEW YORK.

The curve of growth of this great city of the United States is interesting, first, by its comparison with its neighbor, Philadelphia. The curves show that they kept pace with each other very closely from the year 1700 to 1830, when population in New York began to grow with rapid strides and has continued to do so up to the present time, the ratio of increase being greater than that of any other large city in the world except Chicago. The density of the tenth ward, which is on the east side of the city, between the Brooklyn Bridge and Grand Street, is greatest of any in the world, with the exception perhaps of a certain district in the city of Prague, and it may be said advisedly that Sanitary District A of the eleventh ward has the greatest density of any corresponding area of the world, and twice that of Prague in 1893. It comprises about 320 acres, the density in 1890 ranged from 600 to 1,000 inhabitants per acre, or an average of about 512,000 per square mile, the greatest density being 640,000 per square mile. The total population in 1900 was 3,833,999. The present ratio of increase per decade is 37 per cent.

PARIS.

In 1860 the area of Paris was considerably extended by taking in the suburban communes, which increased the population at that time nearly half a million. The density of the population is shown, first, by taking out the squares, or greens and woods, making the average in 1890 on this basis 121,300 per square mile and the area 22.4 square miles. The average of the entire city, including the squares, etc., was 79,500 per square mile, covering thirty-one square miles. The curve of growth of Paris brings out several interesting and important historical points. For instance, the city, as is well known, suffered greatly during the latter part of the reign of Louis XVI. and during the Reign of Terror, from 1774 to 1799, during which period the population actually *decreased*. On the other hand, under the reign of Louis XIV.—1643 to 1715, and that of Louis XV., 1715 to 1754—it greatly prospered, and the growth in the latter period is shown on the curve as having a regular increase. From 1852 to 1870 the Emperor Louis Napoleon did much for Paris, and its growth was very rapid and comparatively uniform. The effect upon the city by the Franco-Prussian war and the Communes is shown plainly on the

Growth and Density of Population of Great Cities

NOTE—
Horizontal Lines represent population by 100,000 nds.
Vertical Lines represent decades of time.
Squares represent density of population in 1885 on the basis
of 100,000 on each square mile = 1/2 inch squared.

BASIS SQUARE FOR COMPARISON.
100,000 POPULATION.

MAXIMUM DENSITY = 630,740 PER
SQ. MILE ON 3.6 ACRES.

NEW YORK

AVERAGE MAXIMUM DENSITY
480,000 PER SQ. MILE ON 320 ACRES.

NEW YORK CITY PROPER
AVERAGE DENSITY = 40,000
PER SQ. MILE, AREA 37 SQ. MILES.

MAX. DENSITY = 132,000 PER
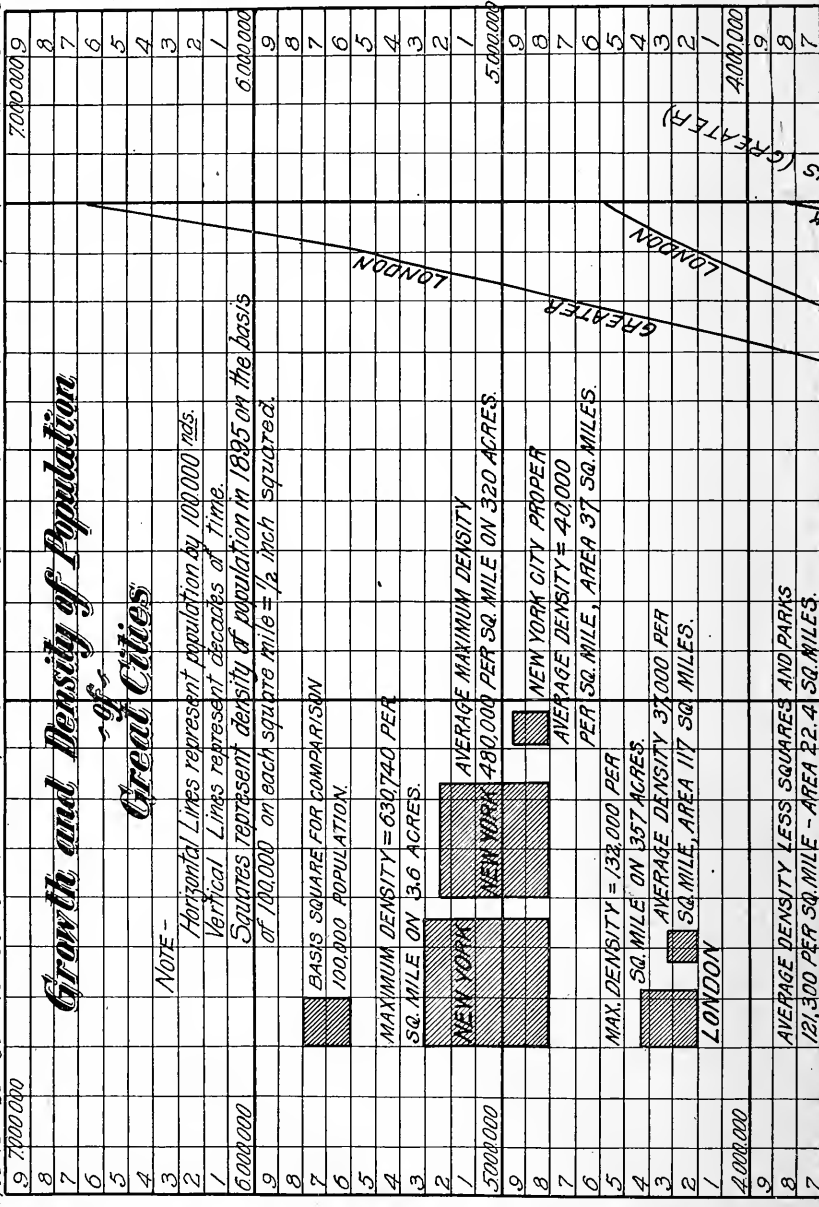SQ. MILE ON 357 ACRES.
AVERAGE DENSITY 31,000 PER
SQ. MILE, AREA 117 SQ. MILES.

LONDON

AVERAGE DENSITY LESS SQUARES AND PARKS
121,300 PER SQ. MILE - AREA 22.4 SQ. MILES.

LONDON

GREATER LONDON

LONDONS (GREATER)

1700 10 20 30 40 50 60 70 80 90 1800 10 20 30 40 50 60 70 80 90 1900 10 20 30 40

7,000,000
9
8
7
6
5
4
3
2
1
6,000,000
9
8
7
6
5
4
3
2
1
5,000,000
9
8
7
6
5
4
3
2
1
4,000,000
9
8
7

MAX.DENSITY DISTRICT 227,276 PER SQ.MILE.

MAX.DENSITY WARD 113,636 PER SQ. MILE.

AVERAGE DENSITY 28,260 PER

ST.PETERSBURG.   SQ. MILE - AREA 33 SQ.MILES.

MAX.DENSITY 92,600 PER SQ.MILE.

AVERAGE DENSITY 67,612 PER

SQ.MILE - AREA 23.4 SQ. MILES.

BERLIN.

PHILADELPHIA.

AVERAGE DENSITY 8,091 PER SQ.

MILE - AREA 129 SQ. MILES.

CHICAGO

AVERAGE DENSITY 8,430 PER SQ.

MILE - AREA 186 SQ. MILES.

LONDON

PARIS

VIENNA

ST.PETERSBURG   BERLIN

PHILADELPHIA-NEW YORK

Growth and Density of Population of Great Cities

NOTE —
Horizontal Lines represent population by 100,000 rds.
Vertical Lines represent decades of time.
Squares represent density of population in 1895 on the basis of 100,000 on each square mile = ½ inch squared.

BASIS SQUARE FOR COMPARISON. 100,000 POPULATION.

MAXIMUM DENSITY = 630,740 PER SQ. MILE ON 3.6 ACRES.
NEW YORK

AVERAGE MAXIMUM DENSITY 480,000 PER SQ. MILE ON 320 ACRES. NEW YORK

NEW YORK CITY PROPER. AVERAGE DENSITY = 40,000 PER SQ. MILE, AREA 37 SQ. MILES.

MAX. DENSITY = 132,000 PER SQ. MILE ON 357 ACRES.
AVERAGE DENSITY 37,000 PER SQ. MILE, AREA 117 SQ. MILES.
LONDON

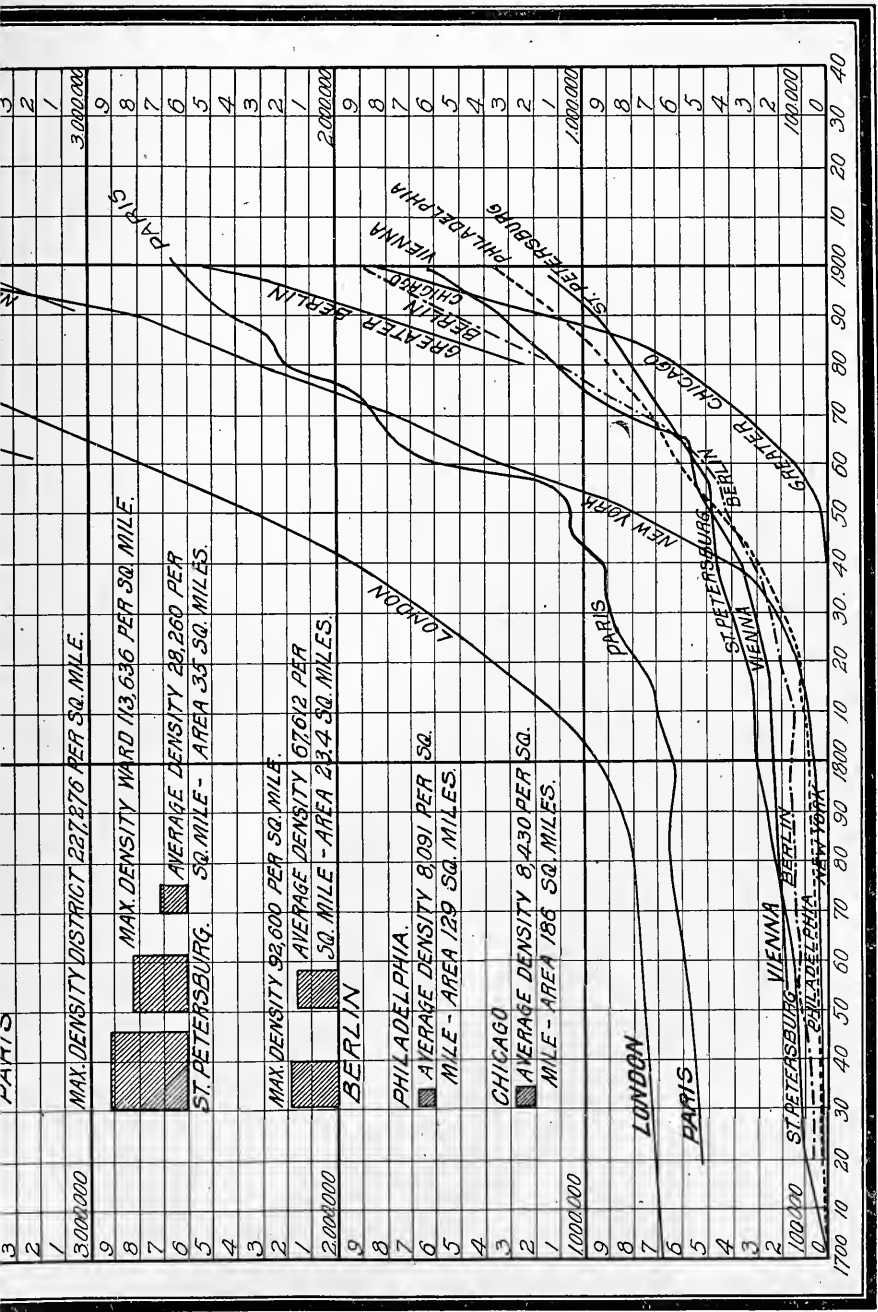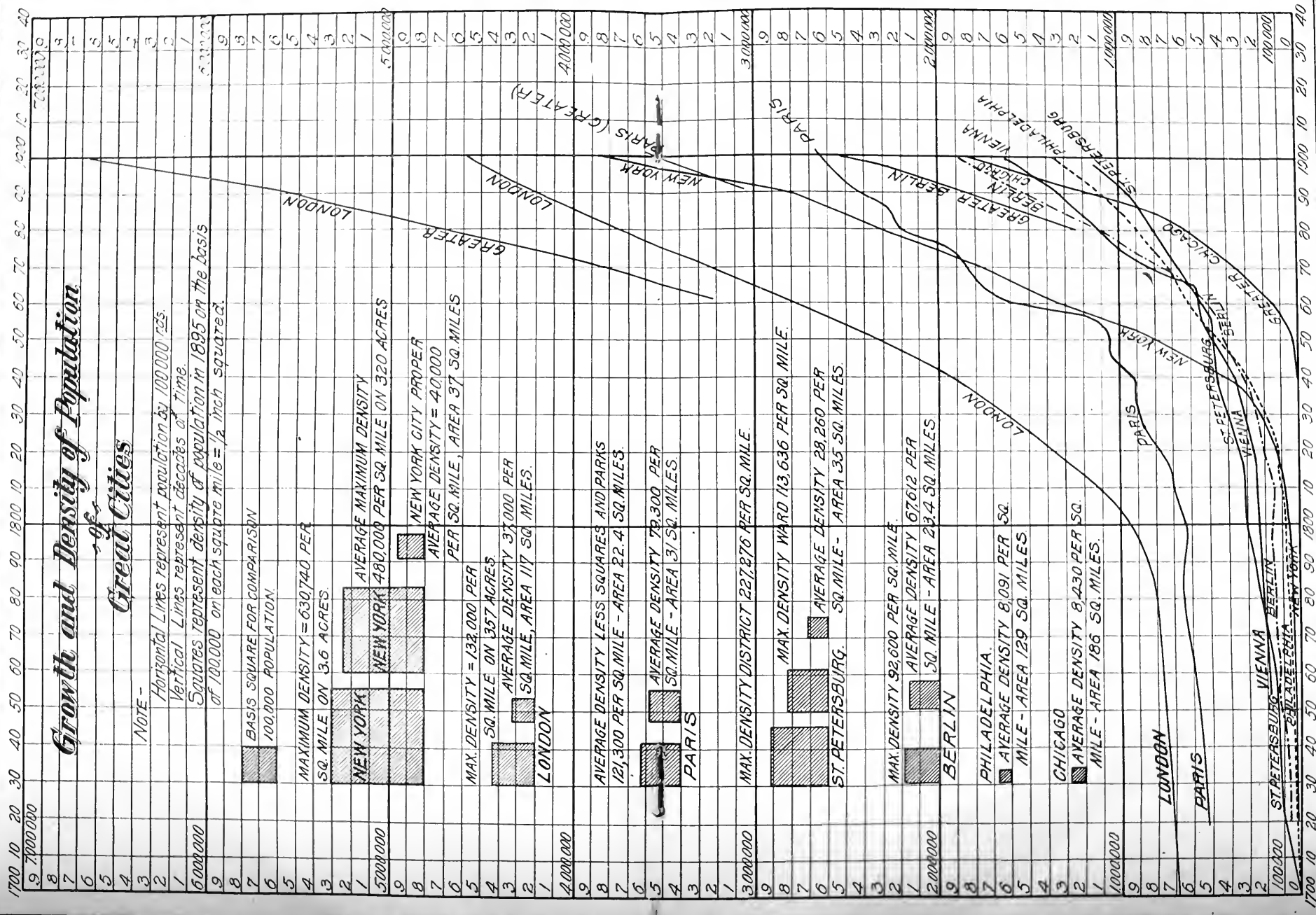AVERAGE DENSITY LESS SQUARES AND PARKS 121,300 PER SQ. MILE - AREA 22.4 SQ. MILES.
AVERAGE DENSITY 79,300 PER SQ. MILE - AREA 31 SQ. MILES.
PARIS

MAX. DENSITY DISTRICT 227,876 PER SQ. MILE.
MAX. DENSITY WARD 113,636 PER SQ. MILE.
AVERAGE DENSITY 28,260 PER SQ. MILE - AREA 35 SQ. MILES.
ST. PETERSBURG.

MAX. DENSITY 92,600 PER SQ. MILE.
AVERAGE DENSITY 67,612 PER SQ. MILE - AREA 23.4 SQ. MILES.
BERLIN

PHILADELPHIA. AVERAGE DENSITY 8,091 PER SQ. MILE - AREA 129 SQ. MILES.

CHICAGO AVERAGE DENSITY 8,430 PER SQ. MILE - AREA 186 SQ. MILES.

Curve labels: GREATER LONDON, LONDON, PARIS (GREATER), NEW YORK, GREATER BERLIN, BERLIN, GREATER CHICAGO, VIENNA, PHILADELPHIA, ST. PETERSBURG, PARIS, VIENNA, NEW YORK

Axis years: 1700 10 20 30 40 50 60 70 80 90 1800 10 20 30 40 50 60 70 80 90 1900 10 20 30 40

Population scale marks: 100,000 · 1,000,000 · 2,000,000 · 3,000,000 · 4,000,000 · 5,000,000 · 6,000,000 · 7,000,000

curve of growth. The population of Greater Paris in 1901 was 3,599,991, New York having outstripped it. The present ratio of increase per decade is 18 per cent.

CHICAGO.

This city, on account of its large area in comparison with the population, had, in 1894, an average of only 8,430 inhabitants to the square mile, its area being 186 square miles. In arriving at the population for 1894, it was necessary to use considerable judgment in deciding which census should be employed. There had been estimates made of over 2,000,000, but to be conservative the school census of 1894 was used, making the population, including the whole of Cook County, 1,692,727. In ascertaining the ratio of increase, different results are obtained by using different methods of estimating the population, whether by the United States census or by that of the city. The increase from 1880 to 1890 by the United States census was 118 per cent. Comparing the United States census of 1890 with the school census of 1890 the ratio of increase per decade was 106 per cent. If, again, we compare the school census of 1884 with the school census of 1894 we have an increase of 150 per cent. per decade.

The U. S. census of 1900 revealed the fact that all the approximate figures made in 1894 from various censuses were entirely too large. The population in 1900 was 1,838,735, and by the writer's figures 1,692,727, in 1894, both embracing the whole of Cook County, which is assumed to be the metropolitan population. The ratio of increase per decade of 106.5 per cent. was excessive and led to an erroneous prediction of population in the future.

The actual rate of growth per decade based on the U. S. census of 1890 and that of 1900 is only 54 per cent. However, there were important financial conditions affecting the industrial and social status of the city, which led to a decrease in the rate of increase between 1895 and 1900. The financial crash of 1893, when the Columbia Bank and other financial institutions and companies and private individuals went to the wall, had much to do in arresting the growth of the city. The results of this local as well as national and international financial depression did not make itself felt in the population until about 1897 and 1898.

Another cause had much to do with the decreased rate of growth, and that was the industrial reaction

after the World's Fair in 1893. In that year, and for two years previous, while the extensive Exposition preparations were going on, there was an extraordinary influx of population which was compelled to seek other parts of the country at the close of the great fair.

The population in 1900 by the U. S. census was 1,838,735.

The rate of growth based on the census of 1890 and 1900 is 54 per cent.

BERLIN.

The census of this city is taken every year and has been so taken since the year 1720. Consequently, the curve of growth is an entirely different one from that of almost any other city, as the points in drawing the curve are much nearer together on the diagram. As in the city of Paris diagram, so in that of Berlin, the effects of political and military disturbance in the kingdom are plainly seen. The seven years' war from 1756 to 1763 caused a decrease in the population. From 1800 to 1810, an entire decade, there is again a steady decrease, and it was during this period that the battles of Hohenlinden, Jena, Auerstadt, Eylau and Friedland were fought with the French. By the peace of Tilsit at the end of this period, Prussia lost one-half of her possessions and kept the other half under very hard conditions. In 1871 the King of Prussia was proclaimed Emperor of Germany, and Berlin became the seat of the empire. From that time the growth has been very rapid, the ratio of increase from 1883 to 1893, the period of maximum increase, being 37 per cent.

In density Berlin stands next to Paris, the maximum density in 1893 being 92,600 per square mile and the average density 67,612, with an area of 24.3 square miles.

Supplementing the explanations already given in regard to Berlin, the population in 1890 of Berlin proper was 1,884,157, and of Greater Berlin, including the twelve districts above mentioned, 2,512,525. And the present rate of increase is respectively 12 per cent. and 19 per cent.

The difference—Berlin and Greater Berlin—is not as great as that between London and Greater London, but still both show the effect of urban and interurban rapid transit by underground, overground and surface lines.

It is safe to predict that the further extensions of those lines and the quickening of the speed will make

the growth of the Greater City in both cases much more rapid in the future than at present. The author is of the opinion that the improvements and extensions contemplated in London by American railway projectors and capitalists will effect a great change in the methods of growth of population.

VIENNA.

The accessible records of population of this city are very incomplete and the curve of population is made from comparatively few dates. The authorities differ considerably as to the population. The fact that the garrison of the city is constantly changing vitiates the the census records.

It is impracticable to secure census returns later than 1899. The population was then 1,617,160, to which should be added a permanent garrison of 22,651 soldiers, making a total of 1,639,811. The population in 1894 on the same basis was 1,480,572. The rate of increase is 11 per cent.

PHILADELPHIA.

There is nothing particularly striking in regard to the curve of this city. It shows a gradual growth and very regular. The density of population is very nearly like that of Chicago, being 8,091 per square mile on an area of 129 square miles. The population, which includes Camden, N. J., which is really a part of the metropolitan population of Philadelphia, is 1,369,632. The rate of increase is 23 per cent.

ST. PETERSBURG.

The effect of the founder, Peter the Great, upon the inception of this city and its growth during two decades is plainly seen at the origin of the curve. In fact, it is generally known that, when it was founded in 1703, compulsory means were employed by him to increase the population to 100,000. Under Elizabeth, from 1741 to 1762, it reached 150,000, and under Catherine II., 1762 to 1796, it reached nearly 300,000. One disturbing feature exists in the census estimates, in that the city has a much larger population in the winter than in the summer, as is well known. The curve of growth includes this winter population and also the immediate suburbs, the object being to arrive at the metropolitan population.

In reference to the density of population, the most thickly settled ward has 50,000 inhabitants, or at the rate of 113,636 per square mile, and the most thickly settled district in that ward had a population of 227,276 per square mile in 1894. The average for the whole city on an area of 350 square miles was at the rate of 28,260 per square mile. The population in 1897, the latest year available, was 1,132,677. In 1890 it was 954,400. The rate of increase is 15½ per cent. per decade.

Recapitulating the statement in regard to ratio of increase at present in the several cities above noted, the following summary is given:

Present ratio of increase,	London.............................. 8.6
" "	Greater London ...:...........20.0
" "	Greater New York.............37.0
" "	Manhattan Borough.........29.0
" "	Paris (Greater) 18.0
" "	Chicago 54.0
" "	Berlin...................:...........12.0
" "	Greater Berlin 19.0
" "	Philadelphia 23.0
" "	St. Petersburg...................15.5
" "	Vienna 11.0

Although the diagram exhibits more effectively the density of population, the following figures will show the basis on which the graphical squares are drawn:

NEW YORK, maximum density, 630,740 per square mile on 3.6 acres.
 Average maximum density, 480,000 per square mile on 320 acres.
 Average density New York City proper, 40,000 per square mile on 37 square miles.

LONDON, maximum density, 132,000 per square mile on 357 acres.
 Average density (Registration London) 37,000 per square mile on 117 square miles.

PARIS, average density, 79,300 per square mile on 31 square miles.

ST. PETERSBURG, maximum density, 227,276 per square mile.
 Maximum density ward, 113,636 per square mile.
 Average density, 28,260 per square mile on 35 square miles.

BERLIN, maximum density, 92,600 per square mile.
Average density, 67,612 per square mile; area 23.4
square miles.

PHILADELPHIA, average density, 8,091 per square
mile; area 129 square miles.

CHICAGO, average density, 8,430 per square mile; area
186 square miles.

As the number of houses and the number of inhabi-
tants per house have much to do with the density of
population, the following items are of considerable in-
terest : New York, in 1894, had 15,000 houses averag-
ing eighteen residents. London, 600,000 houses averag-
ing seven residents; at the beginning of this century it
had only 130,000 houses. Paris had 90,000 houses;
at the close of the Franco-Prussian war it had 70,000,
and at the close of the Napoleonic wars it had only
23,000. The average number of residents in a Paris
house was twenty-five, 40 per cent. greater than in New
York. The most of the public and office buildings in
Paris are utilized for residence purposes, whereas in New
York most of the buildings in the downtown district are
used entirely for business purposes. Taking a square
mile of territory between Wall and Spruce streets and
between Broadway and the East River there was, at
an election a few years ago, only 430 voters, representing
a total population of about 1,750. The unoccupied spaces
in parks, gardens and lawns in Philadelphia is seen from
the fact that, while its population was only about
1,000,000 in 1890, it had 187,000 houses and an aver-
age density of 8,091 per square mile.

The facts on the diagram offer material for interesting
study; such as the influence of national life upon urban
growth, especially upon that of these principal cities;
the serious effect of war upon the growth of cities; the
remarkable change going on in these countries by which
the great cities are pushing upward their curves of
growth; and, what is perhaps of greater interest still,
the quite close approximation that it is possible to make
of the time when some of the curves will intersect and
the rank in population be changed, some outstripping
others and some falling behind their more prosperous
competitors.
An approximate estimate may at least be hazarded,

predicting the population of the cities under consideration at the end of future decades.

Certain important possible changes in conditions need, however, to be considered in forecasting such results, among which are, first, the changes which new methods of transportation may bring about, either taking people more quickly and cheaply into cities, or out of them into more distant districts now open areas or sparsely settled country. Second, the congesting or overcrowding of city areas making them too dense for comfort or health. These two conditions are already producing changes of magnitude in population. London is an instance of these effects or of some others possibly; several of the central districts, instead of showing an increase, showed actual decrease in the last two census epochs.

It is difficult to predict now what change will take place in New York during the succeeding decades by the contemplated transportation changes, such as the opening of the new bridges over the East River, the probable completion of the old Hudson River Tunnel, the construction of the Rapid Transit Subway lines, the electrifying of the Manhattan Elevated and the extension of electric lines into the suburbs, and particularly by the construction of the Pennsylvania Railway's proposed tunnel under the rivers and New York, connecting New Jersey and Long Island with the central district of New York City, and additional facilities for handling passengers at the Grand Central Depot and transferring them to the Subway.

In 1895 the author was in some cases led astray by the erroneous population estimates, as already stated, and his prediction for 1900 based on them and the ratio of increase which showed was far from correct. The causes above stated, which arrested the growth of Chicago, had not shown their influence upon population in 1895.

Berlin may be expected to grow quite rapidly for at least two decades more. As the seat of a comparatively new empire, it is still young, strong, vigorous and ambitious.

And in addition to all other reasons for the continuance in rapid growth of the above mentioned cities, there must be taken into account that of the modern tendency to gravitate to great centers of population, which modern methods of transportation have accelerated.

Even with the above problematic conditions disturb-

ing the future, there is sufficient ground on which to rest a prediction of population, which the author had the temerity to make first in 1895.

He presents this table again, with the actual population as given above, placed in juxtaposition to his predicted population :

	Estimated for 1900.	Actual 1900.	Estimated for 1910.	Estimated for 1920.
Greater London...........	6,496,000	6,652,145	7,490,400	8,516,256
London	4,599,800	4,589,129	4,967,784	5,315,528
New York (Greater) ..	3,900,000	3,833,999	4,953,000	6,191,250
Paris	2,697,300 †2,660,559		2,967,030	3,234,063
Greater Paris..............	.... †3,599,991		4,139,990	4,759,589
Berlin	2,101,400	1,884,157	2,731,820	3,496,729
Greater Berlin.............	....	2,512,523	2,914,517	3,322,549
*Greater Chicago	2,400,000	1,838,735	2,574,229	3,475,209
Philadelphia................	1,414,500	1,369,632	1,697,400	2,002,932
St. Petersburg	1,185,600 ‡1,132,677		1,339,728	1,500,495

*Note.—Chicago. The erroneous estimates of population in 1894 require revision of prediction.

† Population 1901.

‡ Actual population 1897.

The author has endeavored, under difficult conditions and by considerable correspondence, to obtain from time to time the population and other features of the growth of cities of over one million population, hoping that the figures would be of use in solving some of the important transportation, economic and social problems of these great masses of humanity.

It will be necessary, in 1910, to increase not only the population of cities now discussed, but add several to the list; no doubt one or two cities of Great Britain and some in this country, like Boston, and also Buenos Aires, which expects a population of over a million in 1906 or 1907.

ELMER L. CORTHELL, Sc. D.

1 Nassau Street, New York,
    December, 1902.